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DISCUSSIONS ON PAPERS PRESENTED TO CONGRESS.

No. 2—" Lamb Dysentery."[*]

The proceedings of the N.V.M.A. Congress at Newcastle, on Tuesday, September 4th, 1928, commenced with the discussion of Major Dalling's paper on " Lamb Dysentery."

The PRESIDENT (Mr. J. W. McIntosh) occupied the Chair and, at the outset, extended a hearty welcome to any new visitors present. The subject the members had before them was one of immense interest to stock-owners and others, especially to those in that district. Before the discussion commenced, however, he would call upon Major Dalling, who wished to supplement his paper.

Major DALLING then read the following communication :

Continuation of Paper on Lamb Dysentery, published in Handbook of Annual Congress, National Veterinary Medical Association of Great Britain and Ireland, 1928, pp. 55-72.

By T. DALLING, M.R.C.V.S., Langley Court,
Beckenham, Kent.

In the paper referred to above, it was shown that ewes inoculated with antigens prepared from the L.D. bacillus transmitted immunity to their offspring. We have carried out some work recently which has led us to conclude that lambs born from immunised ewes possess no detectable antitoxin at birth and that they receive antitoxin from the mother ewe *via* the colostrum. In our former experiments we had tested antitoxin from ewes and lambs in the course of our ordinary field work : the ewes had been injected twice before lambing and we felt that if we were able to produce more easily detectable immunity in the ewes by hyper-immunising them, we might be able to show definitely how soon after birth lambs showed antitoxin, etc. For this experiment we hyper-immunised a number of ewes by injecting them at intervals during pregnancy with L.D. toxoid until antitoxin was easily detectable in their serum. The ewes were kept under careful observation when near lambing, with the result that we were able to see the actual act of parturition and to bleed the lambs before they sucked their mothers. In all, lambs were born from six ewes so treated. With these animals we have carried out a number of experiments ; only those relating to whether the lamb is born immune or whether it obtains its immunity *via* the colostrum will be described in this paper.

EXAMINATION OF THE COLOSTRUM OF IMMUNISED EWES FOR THE PRESENCE OF ANTITOXIN.

Whenever the ewes showed the presence of colostrum in their udders—sometimes several days or even weeks before lambing—a sample was withdrawn and tested for the presence of L.D. antitoxin. The testing was done by mixing varying amounts of the colostrum diluted in saline with a fixed dose of our test L.D. toxin and, after standing, the various mixtures were injected into mice intravenously. Table 1 is an example of the testing of a sample of colostrum.

TABLE I.

The testing of a sample of colostrum for the presence of L.D. antitoxin.

(0.1 c.c. of a test L.D. toxin used throughout and mixed with the following amounts of diluted colostrum and injected into mice intravenously after standing at room temperature for about one hour.)

Amounts of Colostrum.	*Results.*
0.0035 c.c.	+ +
0.0040 c.c.	+ +
0.0050 c.c.	+ L
0.0060 c.c.	L L
0.0070 c.c.	L L

+ = mouse died. L = mouse lived.

We have shown that the colostrum from immunised ewes, as soon as it can be withdrawn from the udder contains antitoxin. The amounts vary considerably with the individual sheep. Table II shows the results of testing colostrum from three hyper-immune ewes before lambing.

TABLE II.

Ewe.	*Date of lambing.*	*Date of testing colostrum.*	*Units of antitoxin in colostrum.*
A.	29/6/28	20/6/28	1,400
B.	2/7/28	20/6/28	4,000
C.	20/7/28	16/7/28	660

A further sample of colostrum was taken from every ewe within one hour after lambing and before the lamb was allowed to suck. At the same time a sample of serum was taken from the ewe. Tests were carried out for the presence of L.D. antitoxin in both, and a comparison between the amount of antitoxin in the colostrum and that in the serum at the time of lambing shows that there is considerably more antitoxin present in the same volume of colostrum than of serum.

Table III shows this comparison in four ewes.

TABLE III.

Ewe.		*Antitoxin content of colostrum.*	*Antitoxin content of ewe's serum.*
A.	...	500	250
B.	...	2,660	660
C.	...	660	220
D.	...	2,800	800

After the lambs had sucked and at varying intervals, usually of one week, further samples of colostrum were obtained and tests were carried out as above. The results of these tests show that after the lamb had sucked there is an easily detectable drop in the amount of antitoxin contained in the colostrum followed by a gradual fall.

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[*] Paper presented to the National Veterinary Medical Association at Newcastle, September, 1928, by Major T. Dalling, M.R.C.V.S., Beckenham.

Table IV. illustrates this point for one ewe's colostrum.

TABLE IV.

Date.		*Units of antitoxin in colostrum.*
29/6/28	8 a.m.	500
(Lamb sucked about 8-30 a.m.)		
29/6/28	12-15 p.m.	200
30/6/28	10-0 a.m.	25
3/7/28	... ...	10
10/7/28	... ...	5
16/7/28	... ...	2.5
20/7/28	... ...	1.6
27/7/28	... ...	1.4
3/8/28	... ...	2
10/8/28	... ...	1.8

We have carried out a number of experiments to show the relationship between the total solids in the colostrum and milk, the amount of globulin contained, and the amount of antitoxin demonstrated. This, we hope, will form the subject of a further paper—our work would show that there is a distinct relationship between these three.

EXAMINATION OF SERUM FROM LAMBS BORN FROM IMMUNISED MOTHERS FOR THE PRESENCE OF L.D. ANTITOXIN.

Of the lambs from the six ewes only one was not actually seen born. We believe, however, that this lamb had not sucked before we were able to handle it. All lambs were bled at birth and at varying periods afterwards, and in no case have we been able to demonstrate the presence of antitoxin in their serum except in the case of the lamb which was not seen born. In this lamb we were able to show the presence of less than one half, but more than one fifth, of a unit of antitoxin. After a lamb has sucked the presence of antitoxin can be demonstrated in its serum in little over an hour's time. Serum from all lambs has been tested. In some cases they were allowed to suck naturally, but the following is an example of an experiment in which a measured quantity of colostrum was fed. A lamb was born at 10 a.m. on 28/7/28: after being bled, it was fed by stomach tube with 60 c.c. of colostrum withdrawn from its mother's udder at 11 a.m. It was then bled at varying times and received no more colostrum for twenty-four hours when it was returned to its mother and left with her.

Table V. shows results of the tests carried out for the presence of L.D. antitoxin on the various samples of serum obtained from the lamb.

TABLE V.

(28/7/28 at 10-30 a.m. the colostrum contained 500, the ewe serum 200, and the lamb serum no units of L.D. antitoxin.)

Date.	*Time of bleeding.*		*Units of antitoxin in lamb's serum.*
28/7/28	10-30 a.m.	... ...	Nil.
(Lamb fed 60 c.c. colostrum at 11 a.m.)			
28/7/28	11-30 a.m.	... ...	Nil.
,,	12-30 p.m.	... ...	1.2
,,	2-30 p.m.	... ...	16
,,	6-30 p.m.	... ...	40
,,	11-0 p.m.	... ...	40
29/7/28	11-0 a.m.	... ...	25

It is thus evident that antibodies are absorbed by the newly-born lamb after being fed with colostrum containing antitoxin. We have results of experiments to show that the absorption of antitoxin from colostrum by the lamb does not take place when the lamb is four days old. It will be necessary, however, to conduct further experiments to show at what age absorption ceases.

It may be of interest to show one of our tables in which a comparison of the antitoxin content of the milk, ewe serum, and lamb serum is made over a period of time.

TABLE VI.

(Ewe lambed 2/7/28 and lamb was allowed to suck soon after birth).

Date.		*Milk.*	*Ewe Serum.*	*Lamb Serum.*
2/7/28	2-30 p.m.	2,000	660	Nil.
,,	8-30 p.m.	1,400	660	58
3/7/28	2-30 p.m.	660	580	450
6/7/28	... ...	58	500	250
14/7/28	... ...	8	280	110
21/7/28	... ...	70-80	200	110
28/7/28	... ...	2.5	140	66
4/8/28	... ...	2	110	50
11/8/28	... ...	1.8	66	50

The figures refer to the number of units of L.D. antitoxin per c.c.

CONCLUSIONS.

From these and other experiments it would appear that:

(1) The colostrum of immunised ewes contains antitoxin before, at, and after lambing. There is a rapid fall in the amount of antitoxin immediately after the lamb sucks and a gradual fall for several weeks afterwards. The colostrum before and at lambing contains more antitoxin than does an equal volume of ewe serum.

(2) Lambs born from immunised ewes when tested before being allowed to suck possess no demonstrable antitoxin. One suck of colostrum is sufficient to cause demonstrable antitoxin to appear in the lamb's serum in about 1½ hours time. Absorption of antitoxin does not take place when the lamb is four days old.

Mr. T. J. BOSWORTH, B.Sc., M.R.C.V.S., D.V.S.M., of the Institute of Animal Pathology, Cambridge, opened the discussion as follows :—

I understand that the disease known as lamb dysentery was chosen as the subject of a paper to be read at this Conference, firstly because of its prevalence in this locality, and secondly because it was the desire of the Provisional Committee to provide matter which would be of interest to research workers.

That those of us who are engaged in this type of work realise the value of full discussion of the problems we have in hand is evidenced by the existence of a Division of this Association—The Veterinary Research Club—the meetings of which are devoted to this single end. An occasion such as this, however, affords us a unique opportunity of hearing the views of a much larger number of those who are acquainted with this particular disease and especially of those practitioners who live in affected districts. I hope they will not hesitate to give is the benefit of their wide experience and so assist us in the solution of the very interesting and difficult problem with which we are confronted.

We have before us a paper which well merits our consideration, for it is based upon the results of a very large amount of work and is fully up to the standard which we have learned to expect of the writer. We are deeply indebted to him for the trouble he has taken in presenting it.

The distribution of lamb dysentery is certainly somewhat peculiar, but I do not think I quite agree with Mr. Dalling when he describes it as being widespread. The disease assumes serious proportions in a large area comprising the South of Scotland and the North of England and in a smaller area in Wales. Spasmodic outbreaks somewhat resembling this disease are from time to time encountered in various other localities, but in the majority of cases it is difficult or impossible to determine whether they are in fact identical with it. Such outbreaks are usually isolated and shew little or no tendency to recur in subsequent years, thus differing from what is seen in lamb dysentery districts. Reports of the occurrence of this disease in other countries should, I think, be received with caution until we are in a position to apply some more definite standard of comparison than we at present possess.

Lamb dysentery has engaged the attention of quite a number of investigators during recent years. I believe they are all agreed as to the organisms that are constantly present in the intestines of affected animals and as to the fact that, in a small minority of cases, one or more of these organisms invade the body by way of the gut wall and can be found in the blood and in some of the internal organs. Differences of opinion do, however, exist as to the significance that should be assigned to these various organisms. For some, *B. coli* is of importance in that it produces a condition of the gut wall that is favourable to the action of *B. welchii,* and thus both organisms play a part in the etiology of the disease. For others, the presence of a highly toxigenic variety of *B. welchii* affords a sufficient explanation. Others, again, have doubted whether the disease is primarily of a bacterial nature at all. Personally, I doubt whether the action of any one of the organisms so far described or any combination of them can be held to afford a full explanation of the etiology of this disease. I have arrived at this conclusion only after the repeated attempts on the part of my colleagues and myself to prove the contrary have ended in failure. In particular, we have been unable to reproduce the disease in lambs by the oral administration immediately after, or within a short time of, birth of cultures of *B. coli* and *B. welchii,* either separately or combined. In spite of the failure of our earlier efforts we have repeated the experiment during the past season on a further twenty-eight lambs, using pure cultures of *B. welchii* but with entirely negative results. The strains used were isolated from acute cases of the disease and were highly toxigenic.

Some years ago we tried the effect of the injection of mixed cultures of *B. coli* and *B. welchii* direct into the lumen of the small intestine, but the inoculated animals remained quite healthy. These results appeared to us to point to the operation under natural conditions of some other factor, organismal or otherwise.

Certain epizootiological considerations are also in favour of this view. It has been shewn, for instance, that when ewes in the later stages of pregnancy are moved from infected to clean land a proportion of their lambs die of dysentery. This fact can be explained according to the theory advanced by Mr. Dalling in his paper by assuming that the ewes carry *B. welchii* with them. But, on the other hand, some farms have remained free of the disease in spite of the fact that draught ewes from infected farms have been brought in and have presumably also been carriers of this organism.

Again, one must bear in mind the large annual traffic in sheep which results in animals from affected districts being widely distributed throughout the country generally. Many of these are subsequently used for breeding purposes, but their dispersal is not followed by the occurrence of numerous outbreaks of this disease, in spite of the fact that they are often kept under conditions in which the soil is likely to become heavily contaminated by an organism like *B. welchii.*

Then again, in the affected districts themselves, it is often found that a farm remains clean although it is adjacent to one or more infected farms and there is frequent intercommunication of animals along the boundary.

We will now turn to the most important part of Mr. Dalling's paper and briefly examine the reasons which have led him to conclude that the type of *B. welchii* found in lamb dysentery cases is the actual cause of the disease.

1 and 2.—" The organism has been isolated from ulcerated areas of the intestinal tract of diseased lambs and in some cases from the tissues of diseased lambs."

All investigators are agreed on these points, but they are, of course, equally applicable to other organisms, such as *B. coli* or the enterococcus.

3.—" The organism is not found, as far as our experience goes, in healthy lambs."

This statement is necessarily of a qualified nature, owing to the limited number of healthy animals examined, but it would be interesting to know if it applies to such animals on affected farms.

4.—" Soil from infected areas has been shown to harbour the organism but it has not been found in other soils."

It would hardly be safe to assume that, because the presence of this organism could not be demonstrated in a few samples of soil from other areas, its distribution is therefore confined to land on which the disease occurs. In this connection it is interesting to note the observation of the distinguished French scientist, Weinberg, that anti-welch serum prepared in his laboratory affords protection against one of Mr. Dalling's lamb dysentery strains of *B. welchii* for, if such is the case, it tends to show that the distribution of this organism is not very limited.

Certain other criteria which the author uses to distinguish the lamb dysentery organism from other members of the *B. welchii* group do not appear to be absolute.

For instance, some workers have found that a minority of strains of *B. welchii* show distinct proteolytic characters and so resemble the lamb dysentery organism in this respect. Others have found that certain strains do not ferment glycerine. The composition of the toxin of different strains is also held to show considerable variation. Some strains produce a toxin largely composed of hæmolysin, whereas that of others is composed mainly of a non-hæmolytic factor. Even a single strain has been shown to vary in the type of toxin it produces. At one time it may produce a toxin composed mainly of hæmolysin, and, at another, a toxin which contains only a very small fraction of this substance.

Then again, I am not quite clear whether the presence of this organism in cases of so-called " milk ill " applies only to lamb dysentery farms or whether it has been found in these cases on land where lamb dysentery has never been known to occur.

Quite apart from this, a few years ago one of my colleagues isolated an organism resembling *B. welchii* from sheep in a district remote from any outbreak of lamb dysentery. This organism was found to be very toxigenic and appeared to be serologically distinct from a type strain of *B. welchii* in that its toxin was not neutralised by serum prepared from the latter.

5.—" The disease has been artificially reproduced by the use of this organism on healthy young lambs from non-infected areas."

This statement is based upon experiments in which a highly virulent culture of *B. welchii* was adminstered to young lambs either by feeding or by intravenous injection. The latter method automatically ensures the introduction of the organism into the various tissues of the body and positive results obtained by such means hardly afford an explanation as to how the organism secures a foothold in natural cases. In such cases the organism is, presumably, taken in by the mouth, but in order to reproduce the disease experimentally by this channel it is apparently necessary to use cultures the virulence of which has been artificially raised, and also, according to the author's earlier publications, to administer them in considerable doses. There, again, I do not think that the results obtained help materially towards a solution of the problem. Indeed, one might argue that they are not inconsistent with the idea that in cases of lamb dysentery, *B. welchii* plays the part of a secondary invader, analogous to that of *B. suipestifer* in swine fever.

6.—" Lambs may be protected against lamb dysentery by the use of antigens and antitoxins made from this organism."

There, again, it may be a question of protecting animals against a highly pathogenic secondary invader which happens to be an extremely good antigen.

In spite of these objections to the view that *B. welchii* is in itself the cause of lamb dysentery, we have long held the opinion that it plays an important part in this disease. Under conditions, whatever they may be, that allow the organism to become established, the elaboration and absorption of its toxin can be held to explain the death of the animal.

The appearance of lambs in the later stages of the disease is consistent with an intoxication, as are the histological changes produced in certain of the internal organs. The success which has followed the use of specific antitoxin as a prophylactic shows that such intoxication is due to this organism. These facts, however, do not seem to afford a full explanation of the etiology of the disease. There are many points which still remain obscure and further research is necessary to complete our knowledge of this condition. In the meantime, it is very satisfactory to know that Mr. Dalling has obtained such good results with the preventive measures he has devised. These should prove of great economic value where the annual losses are severe. I do not think we should relax our efforts on that account, however, for like all forms of inoculation involving large numbers of animals, they entail considerable trouble and expense and where losses are more moderate in numbers, the economic factor is likely to preclude their use. In conclusion, I would like to refer to the interesting observation that the blood of 20 per cent. (roughly) of ewes on an infected farm was found to contain a detectable amount of antitoxin. One would think that if it is a general rule that animals become immunised naturally, the number of cases of lamb dysentery on farms where breeding is confined to home-bred animals, would gradually diminish year by year. I do not think that this is so, but perhaps the immunity thus obtained is not sufficiently strong.

Mr. W. A. Pool (Animal Diseases Research Association, Edinburgh) :—

I congratulate Mr. Dalling on the paper he has presented and the work he has carried out on lamb dysentery. It is a most important disease of sheep and causes greater loss than is realised. I estimate that in Scotland alone it has caused losses amounting to at least £100,000 annually in recent years.

The paper should have been entitled " Immunisation against Lamb Dysentery," because that aspect of the question has chiefly been dealt with and etiology and methods of spread and infection have been given inadequate attention.

The evidence put forward cannot be accepted as proof that a type of *B. welchii* is the cause of the disease. It is necessary to elaborate this point as very few, outside of those who have been closely connected with the investigations, have any idea of the work which has been carried out or the results which have been obtained.

At least twenty investigators from five different laboratories have studied the disease during the last 8—9 years. Actually, most of the experimental work undertaken by the different investigators is unpublished and it is quite doubtful if it will ever see light.

A sub-Committee of the Agricultural Research Council has been considering the question since 1925. At its formation the laboratories represented submitted reports embodying the general nature of the work undertaken and results obtained to date and in the interim there has been very free exchange of information between the members of the Committee. The general position will be well illustrated if I indicate the trend of opinion when in 1926 I took charge of my present duties.

The reports of the Committee indicated that there was very considerable doubt if the disease was contagious or if it could be set up artificially in lambs. All attempts at the hands of certain investigators had produced negative results.

Bosworth and Paul had stated in the course of correspondence published in the *Veterinary Record* in 1925, that there is definite proof that infection occurs before birth.

Close scrutiny of the actual published work revealed strange contradictions. In one case a lamb dosed with a *B. coli* culture contracted the disease. In the nineteen instances on record of lambs dosed with *B. welchii* type of cultures, nine lambs remained healthy and ten died from dysentery.

In the correspondence from Bosworth and Paul referred to above there was strong opposition to the view that lamb dysentery is contagious. Bosworth stated that sanitary precautions, based on the belief that the infective agent lies in the fæces of affected lambs, are useless. He considered infection to occur *in utero*. Paul stated that he was satisfied that the disease is neither infectious nor contagious.

All this is, I think, sufficient evidence of the chaotic views held as to the etiology of the disease. Most of the experimental work had been carried out in field laboratories in an infected area, and in consequence, in each individual case one is entitled to assume, unless there is absolute proof to the contrary, that a positive result was due to the fact that the animal concerned was already in the incubative stage of the disease. As an illustration of this point, there was an instance in which one of the experiments carried out under the direction of the Lamb Dysentery Committee was ruined by the fact that a case of dysentery was found on a farm in Northumberland, from which supposed clean ewes were sent to the South of England.

In consequence of these circumstances, I felt bound to start experiments in 1926, which would guard against the fallacies mentioned. That work is now in course of publication.

The Animal Diseases Research Association has carried out systematic work on immunisation against the disease since 1921 and gradually worked up to the point that we also find that lambs can be protected with a serum prepared from *B. welchii* types of organisms obtained from cases of lamb dysentery.

This, however, would agree with the work of Williams on the share of *B. welchii* in intussusception and peritonitis in human beings, in which the organism is found to produce its toxin and cause death as the result of pathological conditions set up in the bowel by other factors.

I would like to know why Mr. Dalling inoculates the ewes in the autumn. Is this to meet the view that infection is ante-natal ? His collaborator, Paul, is an avowed ante-natal infection supporter and I would like to know if he tries to protect the embryo before it acquires infection.

The really critical experiment on the etiology of lamb dysentery would be to test the effect of strains of *B. welchii* on lambs removed aseptically from the uterus by cæsarian section and reared aseptically in absolutely enclosed aseptic boxes. There is a certain amount of literature on the subject of rearing even mammals in this way, and though tedious, the work could be done.

The disease is on the wane now in many parts of the country and it is possibly easier to protect at that stage than when it is in its more virulent stage.

Certain proprietary powders have been used on an enormous scale on infected farms during the last two years. The results are said to be exceedingly good, though odd farmers have found them to be useless.

I deprecate the habit into which some members of the profession appear to be in danger of falling, of looking for an easy way of using a prophylactic agent and neglecting the application of sanitary science to the control of disease. Very little, if any, skill is required to buy a specific serum or vaccine and inoculate it. The practising veterinary surgeon can utilise his specialised knowledge far more than appears to be realised either by the profession or by its clients.

Lamb dysentery is a disease *par excellence*, in which the specialised knowledge of the practising veterinary surgeon can save the owner of the sheep of an infected farm great losses by giving him detailed instructions as to what measures should be carried out, where great attention should be given and where it is a waste of time. To do this, he must be in possession of accurate knowledge of the nature of the disease and the manner in which it is spread as well as of the management of the farm concerned. Merely to tell a farmer to have all his ewes or lambs inoculated will, in many or most cases, lead to greater expense than that involved by the potential losses.

Mr. W. Lyle Stewart (Armstrong College, Newcastle-upon-Tyne) : I should first of all like to add my personal quota of thanks to Mr. Dalling for the interesting account of his work on lamb dysentery which he has given us, and also to Mr. Bosworth for opening the discussion. Northumberland, possessing as it does more sheep stock than any other county and having suffered most severely from the ravages of the disease, Northumbrian farmers should find a particular significance in the conclusions which have resulted from Mr. Dalling's work. However, unfortunately from the investigational point of view, very little vaccination of ewes has been tried in this county during the past two years, and consequently I am not in a position to give Mr. Dalling's results an unqualified confirmation. I agree with the essayist when he says that lamb dysentery under various local names has been known for many years, and many shepherds can recollect the disease on the Cheviot Hills sixty years ago. One farmer told me that an old shepherd in the employment of his father used to " pray for a snowstorm to drive the milk off the ewes at lambing time." This was on account of the " milk-ill," which I believe to be the same disease as " lamb dysentery." Generally speaking, the disease in Northumberland has waned during the past two years and a number of immunity experiments planned by me have had indefinite results due to the insignificant difference in the death-rate of lambs born from inoculated ewes and from uninoculated or control ewes. However, on seven farms with a reputation for lamb disease I have vaccinated 627 pregnant ewes, using a preparation of Mr. Dalling's organism as antigen. The total number of lambs born from these ewes was 722 and 13 or 1.8 per cent. died from lamb disease. Altogether on those farms 798 ewes were left untreated to serve as controls. They gave birth to 835 lambs, of which 37 or 4.4 per cent. died from the disease. I may say that the results on some individual farms were extremely good, but the incidence of disease on other farms was so small that definite conclusions could not be drawn. Vaccination of pregnant hill ewes was, in my experience, a perfectly safe procedure, and I am of the opinion that the vaccine was responsible for reducing the death-rate as stated above. I would still like to see its effect in a really virulent outbreak. With the evanescent incidence of the disease in this country, such a clear-cut experiment must, of course, be a matter of chance.

Mr. Dalling has indeed woven a closely-spun web of evidence against the *B. welchii*-like organism, incriminating it in the causation of lamb dysentery. In his immunological work and serological testings, nothing seems to have been omitted. Not only have Koch's postulates been fulfilled for what looks like a newly-discovered pathogenic organism, but strong confirmation has been obtained by him from practical tests carried out in the field, and it would certainly appear as if yet another important sheep disease had been successfully conquered.

Five cases were put under examination, three of which were given hyper-acute lamb dysentery cases and the two remaining as typical milk-ill cases.

In each case a *B. welchii*-like organism was isolated and purified by one or more (or a combination of) the following methods :—

(1) Portions of the intestine smeared over the surface of sterile porcelain plates and the resultant dried material inoculated into tubes of casein digest broth (containing minced horse flesh) and incubated at 37°C.

(2) Portions of the intestine inoculated directly into casein digest broth and incubated at 37°C.

(3) Stroked over casein digest agar in petri plates and incubated anærobically (McIntosh and Fildes' method) at 37°C. After 12 hours *B. welchii*-like colonies were subcultured into casein digest broth.

(4) Sets of casein digest broth inoculated in procedures 1, 2 and 3 showing a heavy growth of *B. welchii*-like organisms after 2—4 hour incubation were heated to 80°C. for 30 minutes and subcultured into the same medium.

The resulting growths in all the above cases were rapidly subcultured in the same medium 6—8 times. Plating was now carried out on casein digest agar and incubation at 37°C. for twelve hours followed. Colonies of anærobes (*B. welchii* types only) were rapidly subcultivated in casein digest broth 6—8 times and again plated. This procedure was in each case repeated twenty times, when it was assumed that we were dealing with a pure culture.

In one case (lamb dysentery) we isolated *B. welchii*-like organisms from (*a*) heart blood, (*b*) kidney, (*c*) liver, (*d*) spleen.

SEROLOGICAL.

Toxin.—In all cases doses ranging from .01 c.c.—.0001 c.c., according to medium used for growth, period of incubation, etc., proved fatal for mice. On intravenous injection *B. welchii* culture gave similar results.

Antitoxin.—An antitoxin produced by the use of the typical *B. welchii* proved useless in protecting against the toxins of cases 1, 2, 4, 5a and 5b, while in case 3 the acid antitoxin gave protection. (I.V. injections in mice were used throughout this experiment.)

An antitoxin produced by the use of an L.D. bacillus gave protection against the toxins of cases 1, 2, 3, 4, 5a and 5b. (I.V. injection in mice used throughout.)

If I may say so, there is still a missing link in the essayist's closely-reasoned paper. What is the natural path infected, and how does he account for the rapid spread of disease at the commencement of the cycle ? These are questions which are not discussed by Mr. Dalling, but which seem to have a very important bearing on the subject. Is the infection pre-natal or post-natal ? Following up the work of others, Mr. Dalling has shown that lambs born from ewes which have been actively immunised with antigens made from L.D. bacillus resist L.D. infection and possess L.D. antitoxin. In other words, the lamb possesses passive immunity. Furthermore, we have heard to-day that in all probability the immunity is transferred *via* the colostrum. Theobald Smith has already shown this to be the route in the case of white scour in calves.

Mr. H. G. BOWES (Leeds) : My chief reason for intervening in the discussion is to record the fact, of which Mr. Dalling is apparently unaware (and that is a further indication of the widespread nature of the disease) that it is of very common occurrence in the Craven district of Yorkshire. It has been known there for many years as "ray in lambs." This "ray" was regarded as a form of white scour in lambs. I have made a number of *post-mortem* examinations in the last few years and in every case there was that characteristic ulceration throughout the small intestines which is seen in lamb dysentery. The point has been raised by some of the gentlemen who have entered into the discussion, whether this is an infectious disease. That is a point for the bacteriologists to settle, but so far as the ordinary practitioner is concerned, I think there is no doubt that it is very highly infectious.

The disease is rather seasonal in its occurrence : in some seasons it is much worse then in others. The great point is that once it breaks out on a farm they have the greatest difficulty in rearing lambs. The point was raised as to whether vaccination would be an economic proposition. I am quite sure that the losses are so great in the Craven district that if any form of vaccination is successful it would certainly pay to do it, assuming that the cost of vaccination is not exorbitant. I gather from Mr. Dalling's paper that the more successful method is the vaccination

COMPARISON (CULTURAL AND SEROLOGICAL) OF THE CULTURES ISOLATED WITH A TYPICAL *B. WELCHII* CULTURE.

Cultural.	*Case* 1 *L.D.*	*Case* 2 *L.D.*	*Case* 3 *M. Ill.*	*Case* 4 *M. Ill.*	*Case* 5(*a*) *L.D. Intestine.*	*Case* 5(*b*) *L.D. H.B.*	*Typical B. welchii.*
Action on Solid Serum	Liquefies.	Liquefies.	No Liquefaction.	Liquefies.	Liquefies.	Liquefies.	No Liquefaction.
Action on Alkaline Eggs	Coags.	Coags.	No Coag.	Coags.	Coags.	Coags.	No Coag.
Production of Acrolein in 2 per cent. Glycerine broth ...	—	—	+	—	—	—	+

of lambs, but that it is a more practical method to vaccinate the ewes.

Dr. R. F. Montgomerie (University College of North Wales, Bangor): I have, of course, very much enjoyed reading the paper by Major Dalling and also the discussion up to this point. I wish to ask Mr. Dalling if he has found the *Bacillus welchii*-like organism in lambs suffering from diseases obviously not lamb dysentery? As may be gathered from the paper, I have had a little experience of inoculation, and I say at once that Major Dalling has not got anything down which is not true. I can confirm up to the hilt what he has said as to the results of vaccination, as we find them in Wales. I was impressed very much by the supplementary paper, which Major Dalling gave us, concerning the expression of antitoxin in the colostrum. In Wales the ewes are vaccinated twice, once about three months before lambing and again about ten days before lambing, and the lambs from these do show greater resistance to lamb dysentery than those from uninoculated ewes. I recognise that there are very mild cases of lamb dysentery which do not lead to death and a proportion of lambs merely show signs of it.

It may occur to some of you that the widespread use in treatment by the farmers of a powder preparation may have confused the results which are obtained in Northumberland. I want to make it clear that these powders have not discovered Wales, which is a field where these remedies have not been tried. We understand from Professor Paul that in the early days of the informal Lamb Dysentery Committee they were quite undecided as to whether lamb dysentery was infectious or not. I was invited to join the Committee, and my first impression was that some of us did not quite know the *post-mortem* appearances we would have to find before declaring "lamb dysentery." You must make many extensive experiments before you draw definite conclusions, but the small experiments are more critical because they are small, and thus, I believe, of more value, because one has attempted to do what has been within one's powers. I can say that we confirm absolutely what Major Dalling has stated. As to the question of which method of preventative inoculation is better, I say that with our Welsh conditions I intend to advise the discarding of the inoculation of ewes, because I find that we have not a single death among our inoculated lambs, whereas among the lambs from inoculated ewes we do get an occasional death. It is worth while to expend the extra trouble and labour if that improvement can be achieved; to employ an additional man to enable you to carry out the lamb inoculations rather than that of the ewes. Major Dalling could not deal with everything in the narrow compass of words allowed him, and it is thus inevitable that there should be some disappointments due to omissions. My disappointment is that Major Dalling could not attempt to deal with the question of the regional spread and distribution of the disease. I made an attempt to find a connection between the existence of the disease in the North Wales district and Northumberland, but could secure no conclusive evidence.

Mr. J. R. Barker (Hereford): You have heard this morning quite a number of laboratory workers and I wish to speak entirely as a general practitioner. I can support what Colonel Bowes said about the existence of the disease in the Craven district of Yorkshire, for I resided there from 1908—10, and during that period I often encountered the disease known as "ray." There is no doubt that "ray" in that district is the lamb dysentery which is the subject of our discussion this morning. During that time we took several lambs to the University of Liverpool and Professor Glynn did a lot of work on them, and got so far as to isolate the *Bacillus coli*. My father and myself, in practice, tried to combat the disease with the Metchnikoff lactic acid bacillus and by dressing the navel with carbolic acid in glycerine. Our efforts met with success in reducing the losses on certain farms—it is obvious that it did not eliminate the disease from the Craven district.

This morning we have heard the criticism of two or three laboratory workers by another laboratory worker. I think that Mr. Bosworth is not prepared to accept that the lamb dysentery bacillus isolated by Major Dalling complies with Koch's postulates, neither does Mr. Pool. Mr. Stewart, on the other hand, says he can confirm it. I would like to ask Major Dalling whether he is satisfied that the organism complies with Koch's postulates.

Mr. Jackson Young (Newcastle-upon-Tyne): I wish to thank Major Dalling for bringing before us such an admirable paper. Major Dalling and I have a tremendous lot in common, coming from the same district and from the same College, but there is a matter which we have not in common and that is that he knows a lot of lamb dysentery and I know practically nothing. (Laughter.)

There has been a singular silence this morning on the contents of some of these powders which have been used. These powders have been analysed by Dr. Tocher, and his analysis says that they consist of bismuth salicylate mixed with kaolin. I do feel that sheep farmers should utilise the services of veterinary surgeons more. I keep telling the farmers of Northumberland to go to their veterinary surgeon and ask him to help them, for I am convinced that he could help in many cases. I am old fashioned enough to have some faith in the use of drugs, and we have some reliable remedies for dysentery. We may learn something from the treatment of dysentery in human beings, and I suggest that some of our research workers put some of these preparations in the hands of local practitioners and let them try them. I should like Major Dalling to inform us if emetine has been used in this disease.

THE REPLY.

Major Dalling, replying to the discussion, said:—

The paper has at least given rise to considerable discussion, and this is only to be expected, for this is one of the more recently described diseases. Because of this, lamb dysentery was bound to be the subject of some controversy, but although there has been some discussion to-day, and most of those taking part say they cannot quite see eye to eye with me as to the cause of the disease, I still hold the opinion I expressed, that this particular organism is the exciting cause of the disease. It is a very great pity that the organism was ever called the *Bacillus welchii*. I must bear some blame for this, because when Professor Gaiger and I first saw it, some years ago, it looked like the *Bacillus welchii* and from certain similarities we gave it that name. But it is not the *Bacillus welchii* at all; it is, in reality, quite different.

Mr. Bosworth says the disease is not widespread, but from the discussion here to-day it appears to be even more widespread than I thought. Moreover, we have evidence of its occurrence abroad, *e.g.*, in Peru and (I am quoting other people) in South Africa.

The part played by *Bacillus coli* in this disease wants a little further discussion now. As you know, we thought years ago that that organism was the cause of this disease. We could, however, do nothing with *Bacillus coli.* We carried out examinations of 126 different strains isolated from various lambs which had died or were killed suffering from lamb dysentery, and we could not come to any conclusion as to the grouping of this organism. So we had to describe the *Bacillus coli* as being non-specific in connection with lamb dysentery. The "L.D. bacillus" does produce lamb dysentery in young lambs, but unfortunately we have not been able to use a huge number of lambs. It was only through the generosity of certain farmers that I got lambs for experimental work and practically all the lambs on which I have used this organism have been artificially infected with lamb dysentery. One big field experiment was carried out in Alnwick, for which the Duke of Northumberland purchased for us pregnant ewes from a clean farm and their lambs were used for infection experiments as soon as they were born. The ewes were from a farm where lamb dysentery never has existed, therefore I took it that these lambs were clean and that we were not working with lambs which naturally were associated with lamb dysentery in any way. Our experiments were carried out on a field on which no sheep had ever grazed, therefore there was no chance of any infection having taken place. These lambs developed the disease after being treated with cultures of the L.D. bacillus. Mr. Bosworth criticises the method of inoculating lambs. Intravenous inoculation was one of the ways we tried to reproduce the disease. We also introduced the organisms like *Vibrion septique,* but we were unable to reproduce lamb dysentery thereby.

I agree that an explanation is still wanted as to the natural conditions under which lamb dysentery develops. The more one studies this disease and compares it with other diseases—the more one studies epidermiology as a whole—the less does one seem to know why some animals become infected with diseases and others do not. That is a field of research with which I personally am little acquainted, and it is a very big field for someone to come along and investigate.

Mr. Bosworth points out that other workers have found certain features typical of *B. welchii* which we describe as appertaining to this lamb dysentery bacillus—for example, he says that some workers say that the *Bacillus welchii* may have proteolytic characters. We have studied *Bacillus welchii,* which we have isolated from many sources, and we have not yet been able to satisfy ourselves that the typical *Bacillus welchii* is proteolytic. But this organism which we have described in our paper is definitely proteolytic.

One other point Mr. Bosworth brings up is that in 20 per cent. of ewes on an infected farm we were able to demonstrate antitoxin. He wants to know why an infected farm goes on being infected if antitoxin can be demonstrated in some of the sheep. My answer is that although we are able to demonstrate the presence of antitoxin, there may not be sufficient transmitted in the milk to protect the lamb against the disease, because we have demonstrated in some inoculated ewes which lose their lambs from lamb dysentery, a small amount of antitoxin. Mr. Bosworth also refers to some work that Weinberg did, in which he produced a *B. welchii* antitoxin which protected against our organism or against its toxin. My findings differ from those of Professor Weinberg and I have had some of his serum.

Professor Pool told us some interesting things about lamb dysentery. He began by telling us that the question of etiology had been inadequately dealt with. I would remind you that one would require more than 5,000 words to deal with the etiology alone. He also tells us that a lot of work has not been published; this, I think, is most unfair. If any work has been done I consider that it should be published. (Hear, hear.)

With regard to the question of in-utero infection, though I have not seen Mr. Paul for some months, I believe his last view to be that it did not occur. The question of acute intestinal obstruction in human beings has no bearing on lamb dysentery, because we are not dealing with the *Bacillus welchii* but with this other organism.

Why do we inoculate ewes at these periods? We do so as a matter of convenience, in the first place. We find that farmers are not keen on handling their sheep twice in the spring. Also, from the point of view of immunity, it is possible that a long interval like two or three months between the two inoculations may give a better degree of immunity than the shorter one.

Professor Pool says that the disease is only rare; it is in some districts, but it is increasing in others. He thinks its decline may have something to do with the good results obtained by certain methods of treatment. It has no bearing on our results, as we have had adequate controls all the time.

Mr. Stewart confirms some of the work we have done and said he got some good results, and Mr. Bowes said that this disease is present in Yorkshire—a thing I did not know.

Mr. Montgomerie asks if we find our bacillus in lambs suffering from other diseases than lamb dysentery. That is difficult to answer, because we believe that any lamb which harbours this organism is suffering from lamb dysentery—I mean that although there may be no actual ulceration present in the bowel, if there is an enteritis, and from the intestine this organism can be isolated, then we must conclude that the animal is suffering from lamb dysentery. If Mr. Montgomerie means, have we found this organism in places where there is no epidemic of lamb dysentery and where lambs are dying from some unknown cause, then we have not found it.

Mr. Barker drew our attention to the old method of dressing the navel. We tried it some years ago without much success. I do not know whether we have satisfied Koch's postulates. Using our organism we have reproduced a disease that is clinically similar to lamb dysentery, and have recovered the organism from the animals.

I will not say anything about the powders, except that in our control experiments, if any farmer introduced powders, his results were ignored.

There is still much work to be done on the disease, especially on its epidermiology, and until someone can being forward evidence to the contrary, we shall continue to hold to the view that the organism we have described here is the specific organism responsible for lamb dysentery. (Applause.)

The President returned thanks, on behalf of the members, to Major Dalling for his paper, and also to Mr. Bosworth for opening the discussion.

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